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Spectrum Management from a Training Range Perspective

The federal government faces an increasingly crowded spectrum environment. This presentation introduces the objectives of training ranges and the unique challenges faced by the managers and operators of the spectrum dependent systems that use them. DoD programs currently under development may hold the key to an improved outlook.

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Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE 2012		2. REPORT TYPE		3. DATES COVERED 00-00-2012 to 00-00-2012	
4. TITLE AND SUBTITLE Spectrum Management From A Training Range Perspective				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center - Corona Division, PO Box 5000, Norco, CA, 92878				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Presented at the 33rd annual U.S. Navy-U.S. Marine Corps (USN-USMC) Spectrum Management Conference was held 27 February - 2 March 2012 in San Diego					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 21	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Before We Get Started

- The views expressed in this briefing:
 - Do not officially represent those of the U.S. Navy
 - Are solely those of the presenter
- That said ... ELMO (enough, let's move on)

Hollywood Tries to Help

- **Maverick:** *I feel the need... the need for speed!* 🔊
- **Jester:** *That was some of the best flying I've seen to date - right up to the part where you got killed.*
- **Goose:** *The defense department regrets to inform you that your sons are dead because they were stupid.* 🔊
- **Maverick:** *Too close for missiles, I'm switching to guns.*
- **Maverick:** *[radar beeps] Come on, baby. [tone] I've got him locked... bingo.*
- **Merlin:** *Mustang, this is Voodoo 3. Remaining MiGs are bugging out.* 🔊

Quote source: IMDB movie quotes for "Top Gun"

Top Gun: Paramount Pictures 1986 movie popularized Naval Aviation combat near the end of the cold war. The official title for the U.S. Navy TOPGUN program at the time of the movie was U.S. Navy Fighter Weapons School; now known as U.S. Navy Strike Fighter Tactics Instructor program.



Image source: Wikipedia

Why Training Is Important

- Characteristics of unbeatable armed forces
 - Best physically fit forces
 - Best educated forces
 - Best equipped forces
 - Best trained forces
 - Best informed forces
 - Best lead forces
 - Best supported forces
- Training is crucial if you must accomplish the mission with the least cost (time and lives)



Training Basics

- The “prime directives” of training:
 - “Train As You’ll Fight – Fight As You’ve Trained”*
 - “Do not use artificially improved training capabilities”* –
This would constitute “negative” training
- The prime objectives of training involve
 - *Appropriate training level* (unit, force, joint, coalition, etc.)
 - *Credible opposing forces*
 - *Realistic combat environments*
 - *Recording ground truth (movement, C2, actions)*
 - *Timely feedback and lessons learned*



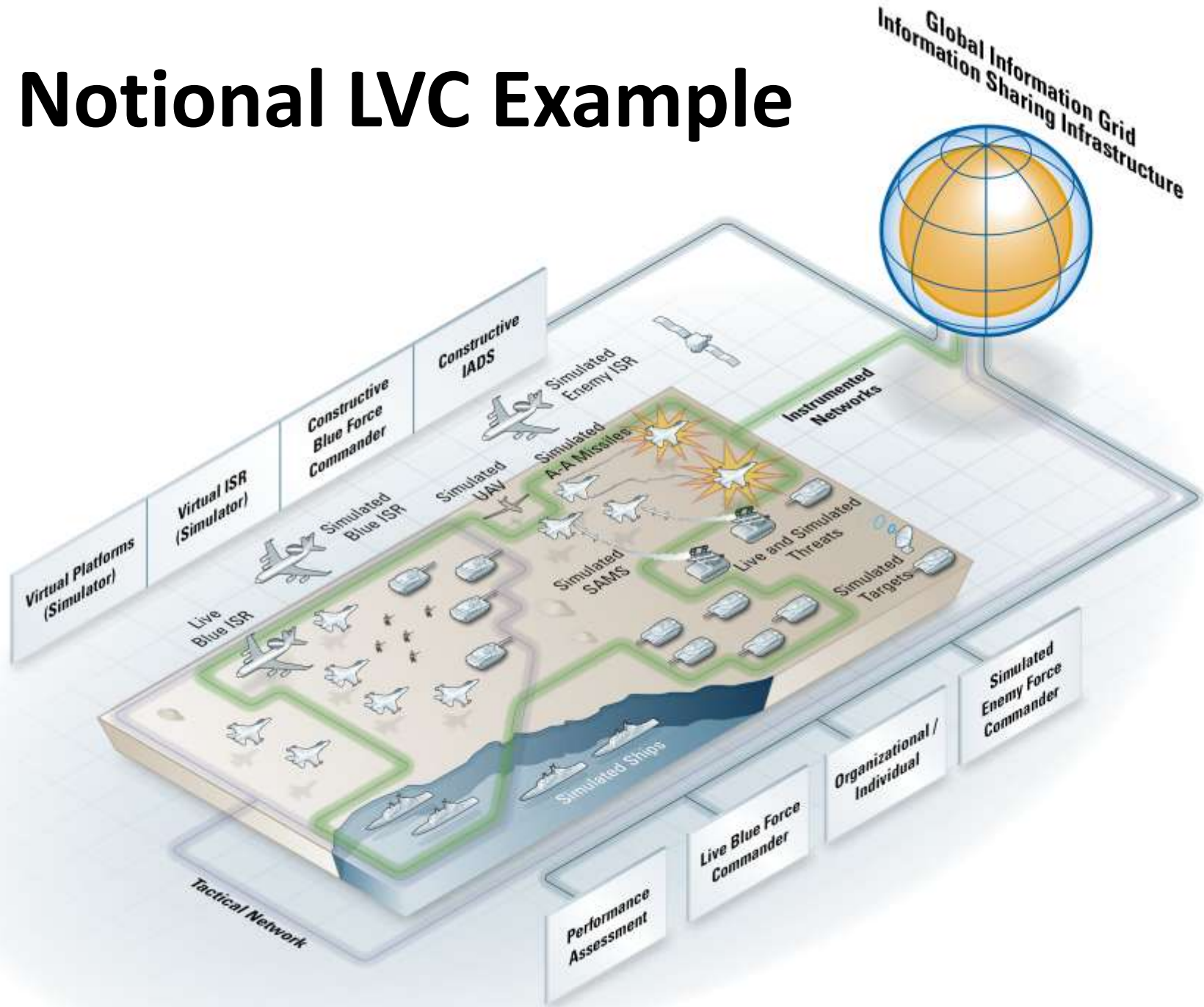
The Realities of Live Training

- Live training is not easy
- Live training issues are numerous
 - Few joint/coalition training venues
 - Safety/airspace/weapons/electronic warfare restrictions
 - Flying time/PERSTEMPO/OPSTEMPO concerns
 - Environmental concerns
 - Complex rules of engagement
 - Funding
 - Availability of frequency spectrum
- To train “live” properly you need real estate, air space, systems and frequency spectrum

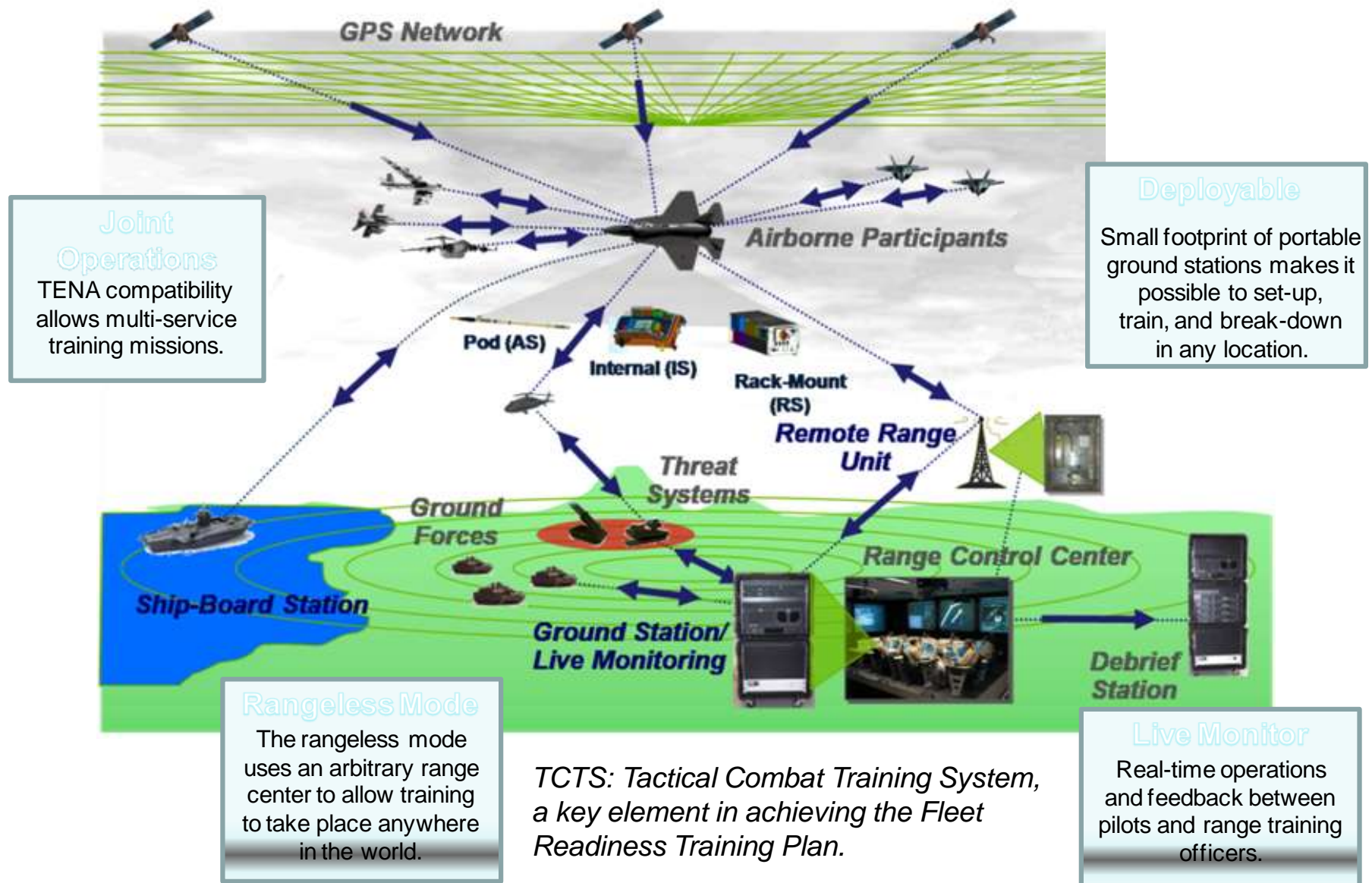
Training Transformation

- Live training constraints have driven a new approach that uses several domains to accomplish goals
 - **Live:** real people operating real systems
 - **Virtual:** real people operating simulated systems
 - **Constructive:** simulated people operating simulated systems
- New approach is dubbed **LVC** (see next slide)

Notional LVC Example



TCTS: LVC Training Example



Major USN Training Ranges Stat



**Training Ranges Provide 75%
of
Naval Aviation Readiness**

TCTS USN/USMC Range Locales



Range Encroachment

- Addressed in OUSD (P&R)'s 2011 *Report to Congress*
 - Part of DoD Sustainable Ranges Initiative
 - Two volumes, 512 total pages
- Report deals with various forms of encroachment (environmental, historical)
- Report cites “frequency spectrum” numerous times
 - Frequent reference to the problem, for example:
“Competition for frequency spectrum will add increased pressure on available bandwidth for Naval operations.”
 - Only one page addresses possible solutions, specifically Table 4-3 (see next slide)

Spectrum Encroachment

Table 4-3 Frequency Spectrum Actions and Milestones

Goal Mitigate Frequency Spectrum Competition

Actions	Milestones
Army	
Create an ACUB to protect spectrum at Fort Huachuca, home of Electronic Proving Ground	<ul style="list-style-type: none"> Complete Phase III and IV of the Fort Huachuca ACUB proposal by 4th Quarter FY2011 (subject to the availability of funding)
Design new ranges to minimize spectrum competition	<ul style="list-style-type: none"> Complete installation of fiber optic cabling to support a wireless network, control targetry, and minimize spectrum and interference on ranges by FY2017
Marine Corps	
Analyze and assess frequency spectrum issues potentially impacting training capabilities at range complexes	<ul style="list-style-type: none"> Assess operational impacts of frequency encroachment at the range complex level (planned FY2011–2012) Incorporate frequency spectrum encroachment analysis and potential mitigation measures into planned ECPs; incorporate updates to existing ECPs (see Goal 1 for schedule)
Navy	
Analyze and assess frequency spectrum issues potentially impacting training capabilities at the range complex and regional level	<ul style="list-style-type: none"> Update the RCMPs and EAPs to identify and assess frequency spectrum conflicts, shortfalls, and the impacts on Navy training (by end of FY2012) Advocate the protection of military frequencies that could be affected by frequency re-allocation and/or the National Broadband Plan
Air Force	
Improve frequency/spectrum considerations in AF basing decision-making	<ul style="list-style-type: none"> Incorporate frequency/spectrum as a key and quantifiable factor in the AF corporate basing process (FY2011)

Range Spectrum Problem

- Federal to FCC spectrum transfer a recurring concern
 - Omnibus Budget Reconciliation Act of 1993 (OBRA-93) ==> Reallocated 237 MHz from federal use to FCC (non-fed use)
 - National Defense Authorization Act FY 2000; requires DoD concurrence, replacement spectrum of comparable utility and replacement funds ==> *actual outcome still uncertain*
- Large volumes of mobile system data exchanged in connection with USN training ranges occurs in the 1755-1850 MHz band
 - This band is also used by DoD T&E range systems
 - This band is among the top bands being considered for transfer to FCC for its “National Broadband Plan”

Generic Answer: New Waveforms

- Dynamic RF bandwidth: to fit actual traffic capacity needs
(not every training mission requires capacity for a Red Flag LFE)
- Tunable across a wide range of frequencies
- Use of non-contiguous spectrum
(a chunk here, a sliver there)
- Channel access matched to user traffic statistics
(TDMA works well for traffic with a Uniform distribution but is inefficient for traffic that fits Poisson distribution statistics)
- Robust immunity against in-band interfering signals
(e.g., via strong Forward Error Correction (FEC) coding techniques)
- Autonomously discover/comply with current assignments
(e.g., via a narrowband ATIS-like beacon channel ~5KHz)

This already is being achieved
(see next slide for example)

Initial Mitigation Example

- ACTS development of data link transceiver waveforms
 - TACTS legacy waveform: multi-lateration based
 - Current TCTS waveform: GPS-based (scheduled TDMA access)
- Next-gen advanced data link (ADL): being developed (agile, robust, efficient)

- Tunable: 1750-2450 MHz
- Spectrum: Any mix of discrete frequencies or contiguous blocks (within a 24 MHz sliding window)
- Dynamic RF bandwidth: 2.5-24 MHz
- Transmit: On-demand (ad hoc)
- FEC and multi-channel access support 12 users transmitting simultaneously (automatic deconfliction)

Available BW (MHz)	Discrete RF Freqs	Max Network Packet Rate (packets per second)	Recommended Max Nodes
24	28	600	160 / 106
20	23-24	600	160 / 106
10	11-12	329	80
5	5-6	114	40
2.5	3	57	15

Another Mitigation

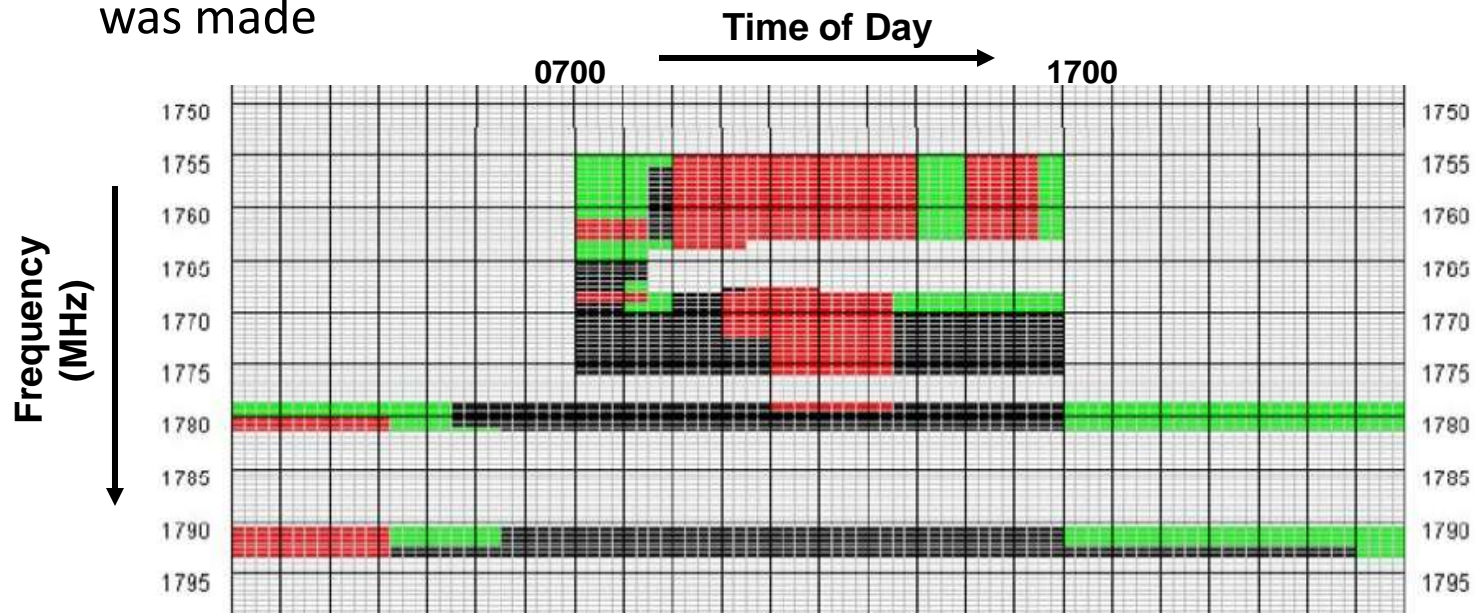
- Dynamic Spectrum Assignment (DSA)
 - Already a permanent working group within the MCEB Frequency Panel
 - Establish DSA for test and training ranges, but a version that operates at human scheduling speeds, not waveform speeds
 - Use existing (and future) US&P spectrum allocations
 - 1350-1525 MHz (traditional “T&E” bands: 1350-1390/1435-1525)
 - 1755-1850 MHz (traditional “training” band)
 - 2025-2110 MHz (possible future relocation: T&E and training)
 - 2200-2290 MHz (traditional “T&E” band)
 - 2310-2390 MHz (traditional “T&E” bands: 2310-2320/2345-2360/
2360-2390)
- New waveforms and DSA not enough (see next slide)

Additional Mitigation

- With training and T&E systems potentially tossed into one band (10 pounds of “stuff” into a 2 pound bag), *one more measure is required*
- Policy: Develop joint T&E/training DSA capability (e.g., *Integrated Frequency Deconfliction System [IFDS]*)
- Technical: Convert IFDS
 - *From: Integrated Frequency Deconfliction System*
 - *To: Interactive Frequency Deconfliction System*
 - IFDS could perform scheduling/deconfliction algorithms
 - Internet-based interactive scheduling for user COI (human timeframe)
 - NB over-the-air frequency scheduling ch. (real-time ops timeframe)
 - Supports extended geographic ops (including inter-range transit ops)

Example IFDS Spectrum Snapshot

- Example is for a USN training range – one day period
 - Time divided into 15-minute increments
 - Frequency spectrum divided into 500 KHz chunks
- Color coded as follows
 - Green: No conflicts
 - Black: Conflicts resolved by applicable range system users
 - Red: Conflicts unresolved; spectrum not used by system for which plot was made



Questions ?

We're just an e-mail or phone call away.

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